UNIVERSITY OF GDAŃSK

aqua VIP

Interreg South Baltic

EUROPEAN UNION

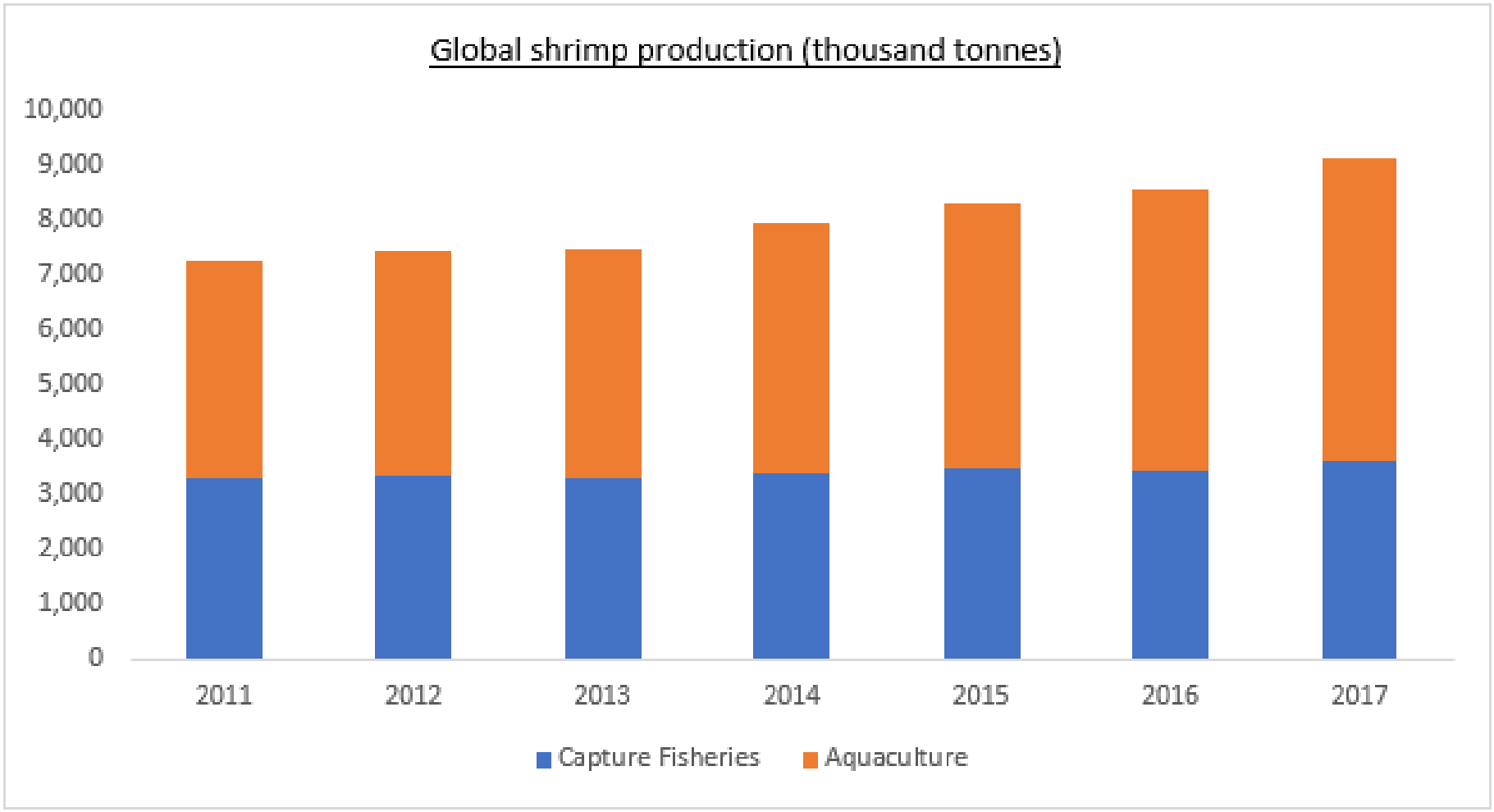
European Regional Development Fund

Small scale shrimp RAS system: design, operation, parameters, results

Halina Kendzierska, Ph.D.

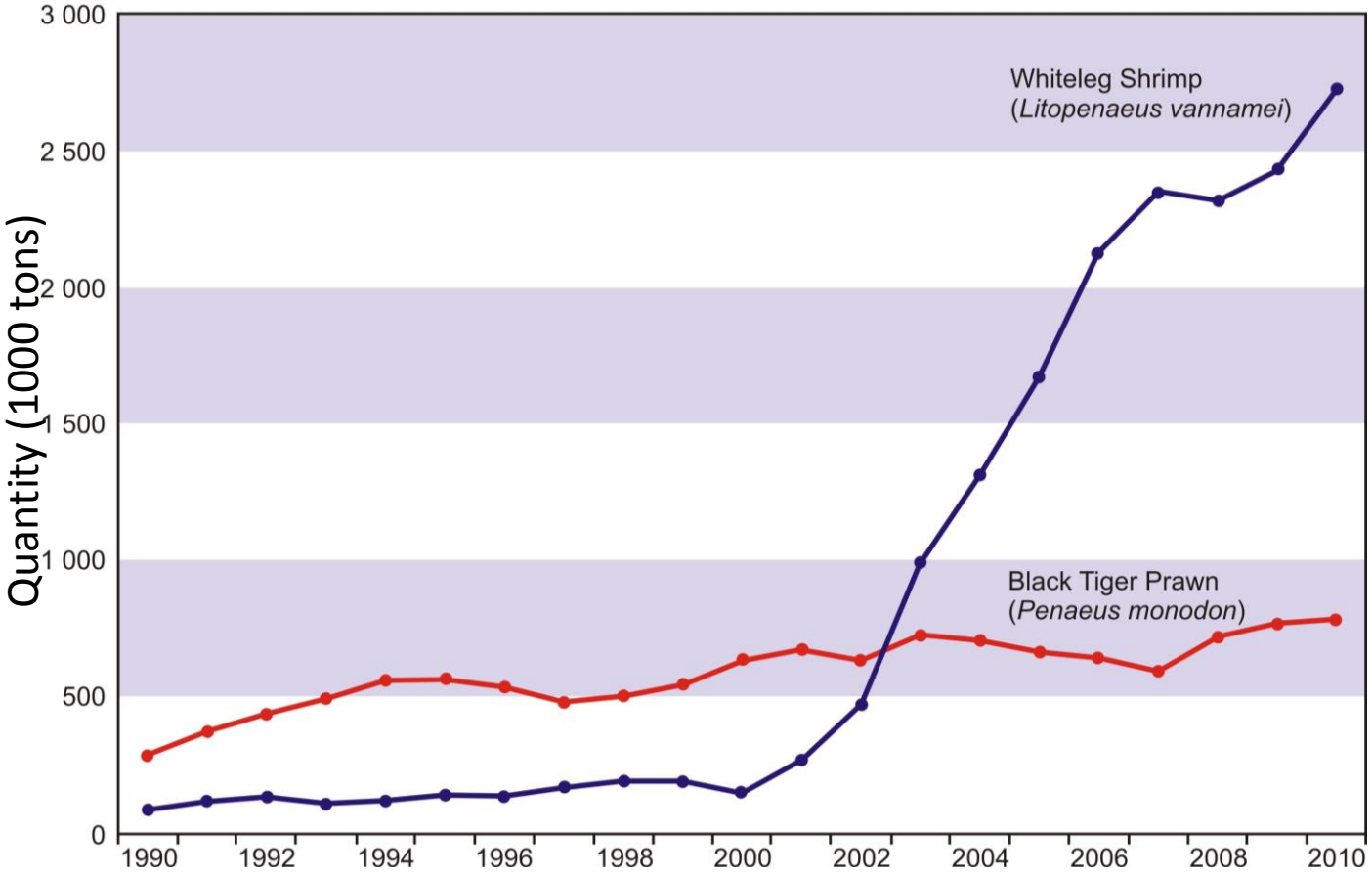
17-20 V 2021, AquaVIP Gdynia summer school

WORLDWIDE PRODUCTION OF SHRIMP



Source: FAO

SHIFT IN WORLDWIDE PRODUCTION OF SHRIMP IN AQUACULTURE



www.eurofishmagazine.com

http://babymarine.com

http://babymarine.com

WHITELEG SHRIMP
PENAEUS (LITOPENAEUS) VANNAMEI (BOONE, 1931)

This shrimp is commonly called the whiteleg shrimp, Mexican white shrimp or white shrimp.

It grows to a maximum weight of approximately 120 g (females). Males are relatively smaller.

This shrimp is greyish-white in color.

Rostrum moderately long with 7-10 dorsal and usually, 2-4 ventral teeth.

WHITELEG SHRIMP
NATURAL DISTRIBUTION AND FARMING AREA

Geographical disribution and area of farming of *Penaeus vannamei* (green) et *Penaeus monodon* (blue).

www.pngegg.com

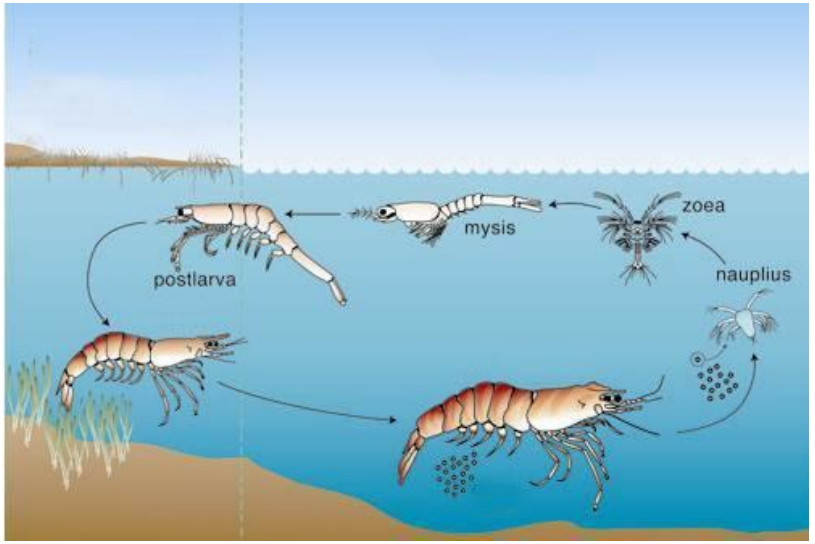
http://en.aquaculture.ifremer.fr

CONDITIONS IN THE AREAS OF NATURAL OCCURRENCE OF WHITE SHRIMP

Parameter	Min	Max
Temperature	23,64 º C	28,79 º C
Silicates	0,76 µmol/L	3,64 µmol/L
Phosphates	0,11 µmol/L	0,25 µmol/L
Oxygen	4,47 ml/L	4,86 ml/L
Oxygen saturation	99,39%	99,54 %
Nitrites	0,19 µmol/L	0,33 µmol/L
Depth	0,5 m	20,65 m (up tp 75 m)

http://www.eol.org/pages/1036948/overview


Photo: : Piotr Kendzierski



Dichmont, C. M. 1987. *Management strategies for an input Controlled Fishery Based on the Capture of short-lived tropical species: the example of Australia's Northern Prawn Fishery* (Doctoral dissertation, University of Tasmania).

WHITELEG SHRIMP
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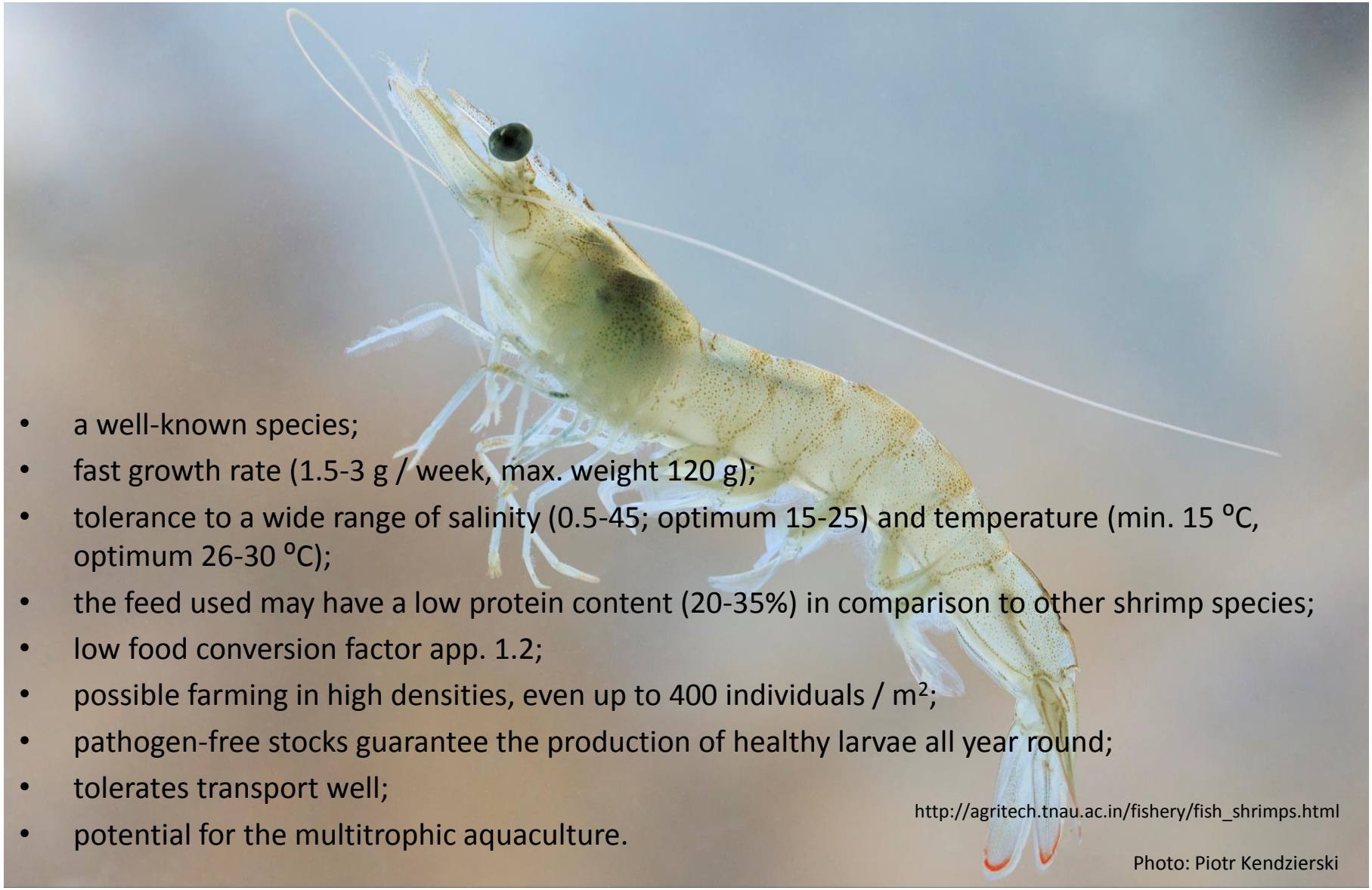


- a well-known species;
- fast growth rate (1.5-3 g / week, max. weight 120 g);
- tolerance to a wide range of salinity (0.5-45; optimum 15-25) and temperature (min. 15 ^{o}C, optimum 26-30 ^{o}C);
- the feed used may have a low protein content (20-35%) in comparison to other shrimp species;
- low food conversion factor app. 1.2;
- possible farming in high densities, even up to 400 individuals / m^2;
- pathogen-free stocks guarantee the production of healthy larvae all year round;
- tolerates transport well;
- potential for the multitrophic aquaculture.

http://agritech.tnau.ac.in/fishery/fish_shrimps.html

Photo: Piotr Kendzierski

WHITELEG SHRIMP FARMING

LAND-BASED PONDS

https://blogs.umass.edu

https://www.worldwildlife.org

https://www.worldwildlife.org

WHITELEG SHRIMP FARMING

www.aquamaof.com

Photo: Valentin Eckart

RECIRCULATING AQUACULTURE SYSTEM

BIOFLOC AQUAPONICS

http://english.vov.vn

RAS - Recirculating Aquaculture System

RAS - water exchange is limited and the use of biofiltration is required.

Advantages

- High conditions control
- Low exposure to pathogens;
- Low environmental impact;
- Flexible locations;
- Independence from external conditions;
- Minimal of space and water need;
- Production of fresh produce,
- Fewer regulatory constraints.

Disadvantages

- High operational costs, mainly electricity and maintenance;
- Increased infrastructure costs;
- Higher skill level staff due the complexity of the system;
- Must provide all feed.

Photo: Halina Kendzierska

THE FIRST EXPERIMENTAL SHRIMP FARM IN POLAND

CROSS-BORDER DEVELOPMENT AND TRANSFER OF INNOVATIVE AND SUSTAINABLE AQUACULTURE TECHNOLOGIES IN THE SOUTH BALTIC AREA

(INNOAQUATECH)

2016-2019

Demonstrating the sustainability and raising awareness for the possibility of crustacean production in RAS systems in Pomerania, Poland

Laboratory study - Growth and nutritional value of *Litopenaeus vannamei* from the small-scale laboratory culture

InnoAquaTech

Interreg South Baltic

UNIVERSITY OF GDANSK

MIR MORSKI INSTYTUT RYBACKI PAŃSTWOWY INSTYTUT BADAWCZY

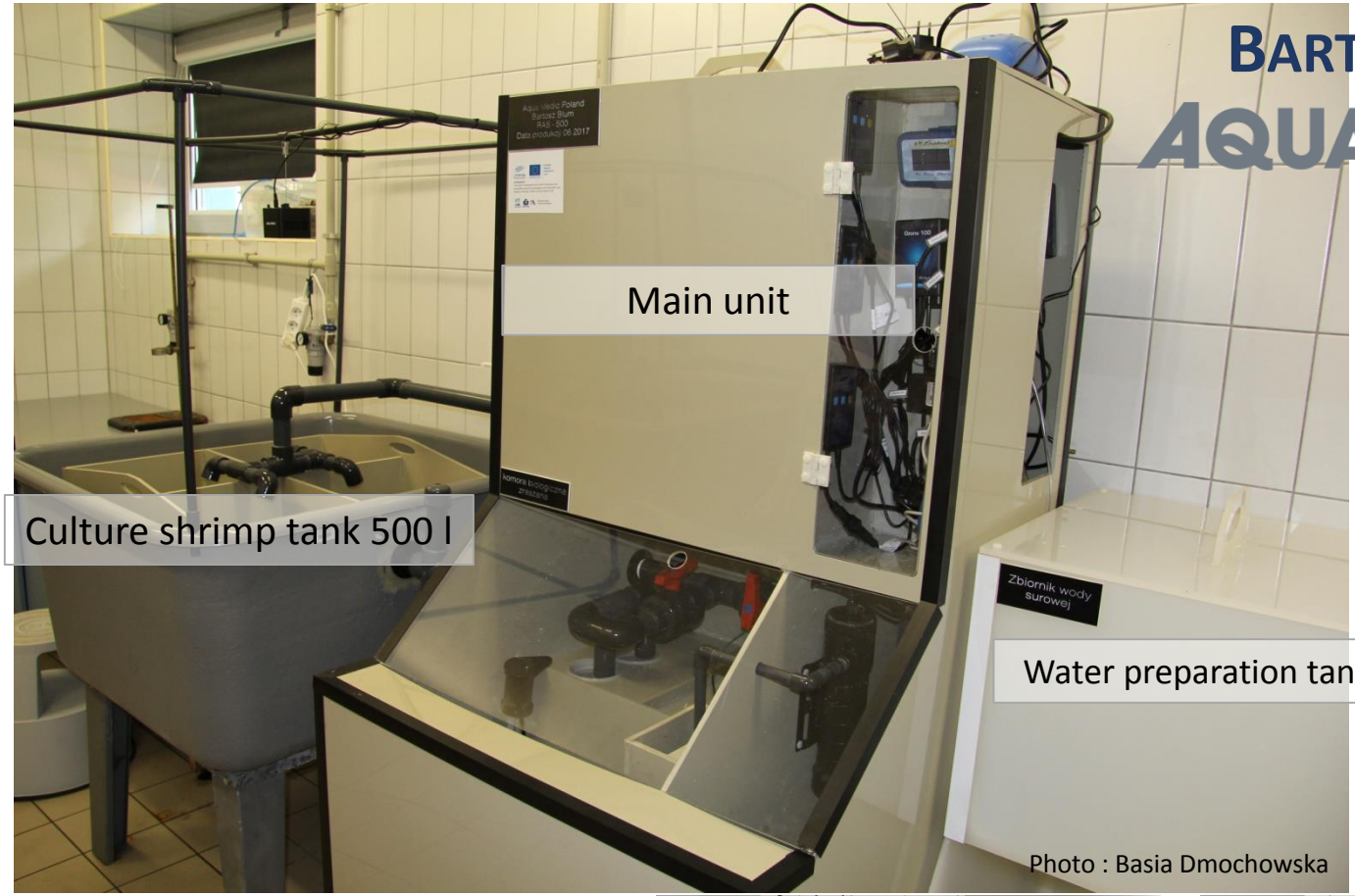
THE FIRST EXPERIMENTAL SHRIMP FARM IN POLAND

Photo: Basia Dmochowska

THE FIRST EXPERIMENTAL SHRIMP FARM IN POLAND

BARTOSZ BLUM

AQUA MEDIC



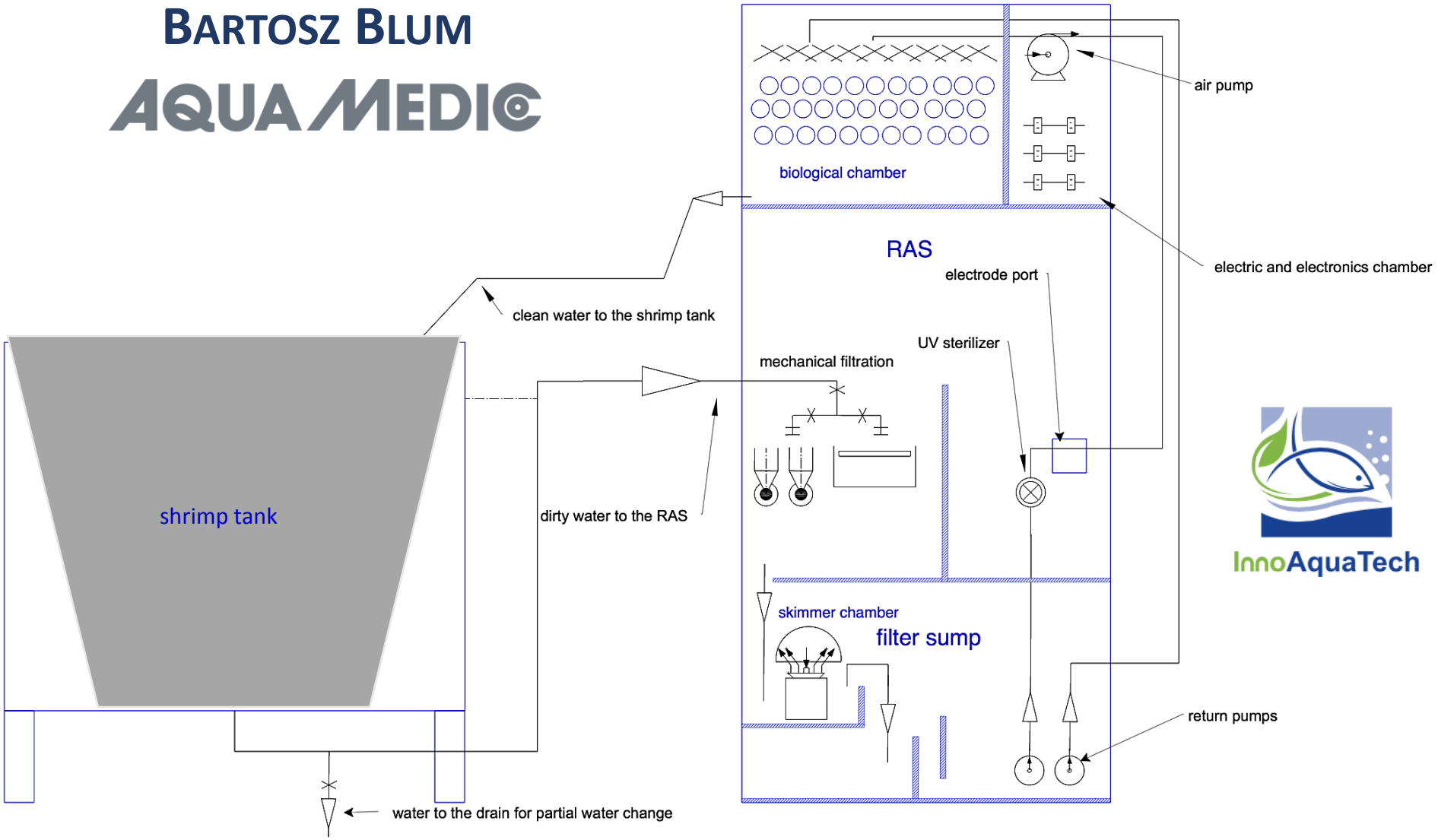
TWO TYPES OF BIOLOGICAL FILTRATION

RAS1 - fluidized bed, RAS 2 - trickling bed

MINI SYSTEM: RAS - 500

BARTOSZ BLUM

AQUA MEDIC

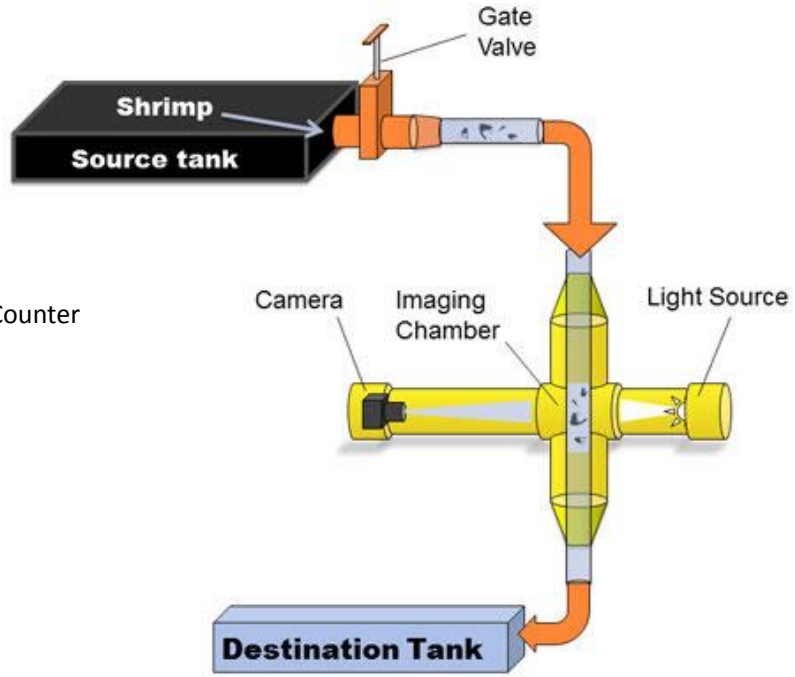


InnoAquaTech

SHRIMP IMPORT

- **The shrimps must be SPS** (*specific pathogen free*);
- Import post-larval (PL) stages shrimp.
- It is common for hatcheries to provide up to 30 % more PL than needed to account for mortality during transport and to boost perceived performance.
- PL counting is usually done by hand, counting a selection of the PL in their bags to estimate the average number per bag. There are some non-manual solutions to complete estimating.

thefishsite.com



The Larcos PL-Counter

community.shrimpstar.com

XperCount

SHRIMP IMPORT

- **The shrimps must be SPS** (*specific pathogen free*);
- Due to unstable weather conditions in US tropical zones and COVID-19 it is recommended in Europe to import shrimps from European hatchery:
  https://euroshrimp.net/europeanhatcherys/

SHRIMP IMPROVEMENT SYSTEMS

White Panther Produktion GmbH

* Transport Mortality Allowance: 20 %

Photo: Halina Kendzierska

SHRIMP ACCLIMATION

- Before shrimp transport the water conditions (temperature, salinity, pH) in the transport should be provide by producer.
- Acclimation is crucial. For reduction of metabolic rate during the transport, shrimps are placed in lowered temperature. Water parameters must be monitor. pH should be increase rather fast (0.1 every 15 minutes). Acclimation to other parameters is slow process.

Photo: Halina Kendzierska

TEMPERATURE

Whiteleg shrimps tolerate a broad thermal spectrum (15-33 °C).

- The most favorable temperature for growth: 23-30 °C:
- Thermal optimum for small specimens (1g): 30 °C
- Thermal optimum of larger specimens (12-18 g): 27 °C.

(Wyban and Sweeny 1991)

- Higher temperatures reduce the likelihood of viral diseases (e. g. WSSV or TSV).

Costs!

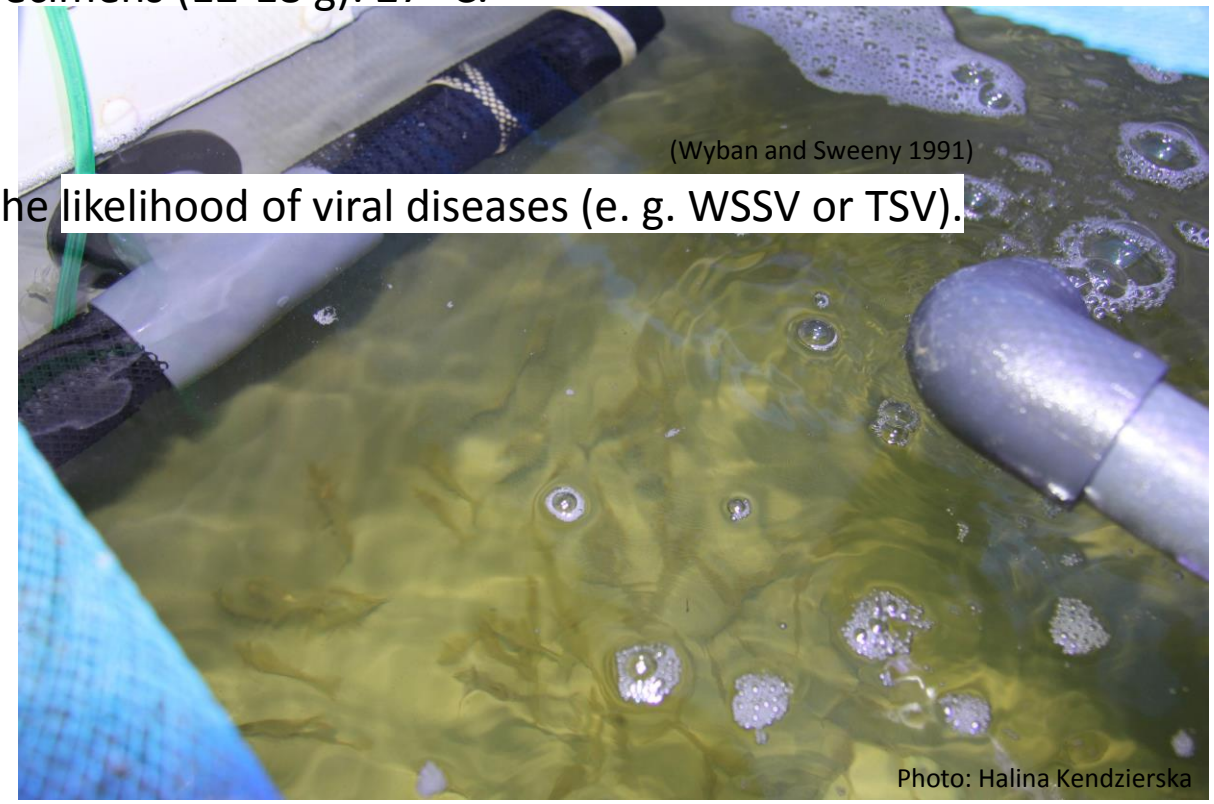


Photo: Halina Kendzierska

SEA SALT AND REQUIRED IONS

- Whiteleg shrimps tolerate broad spectrum of salinity 0.5-45; (experiments up to 65);
- The cultivation is carried out in the salinity range of 7-34;
- Adult the iso-osmotic point is 10-15;

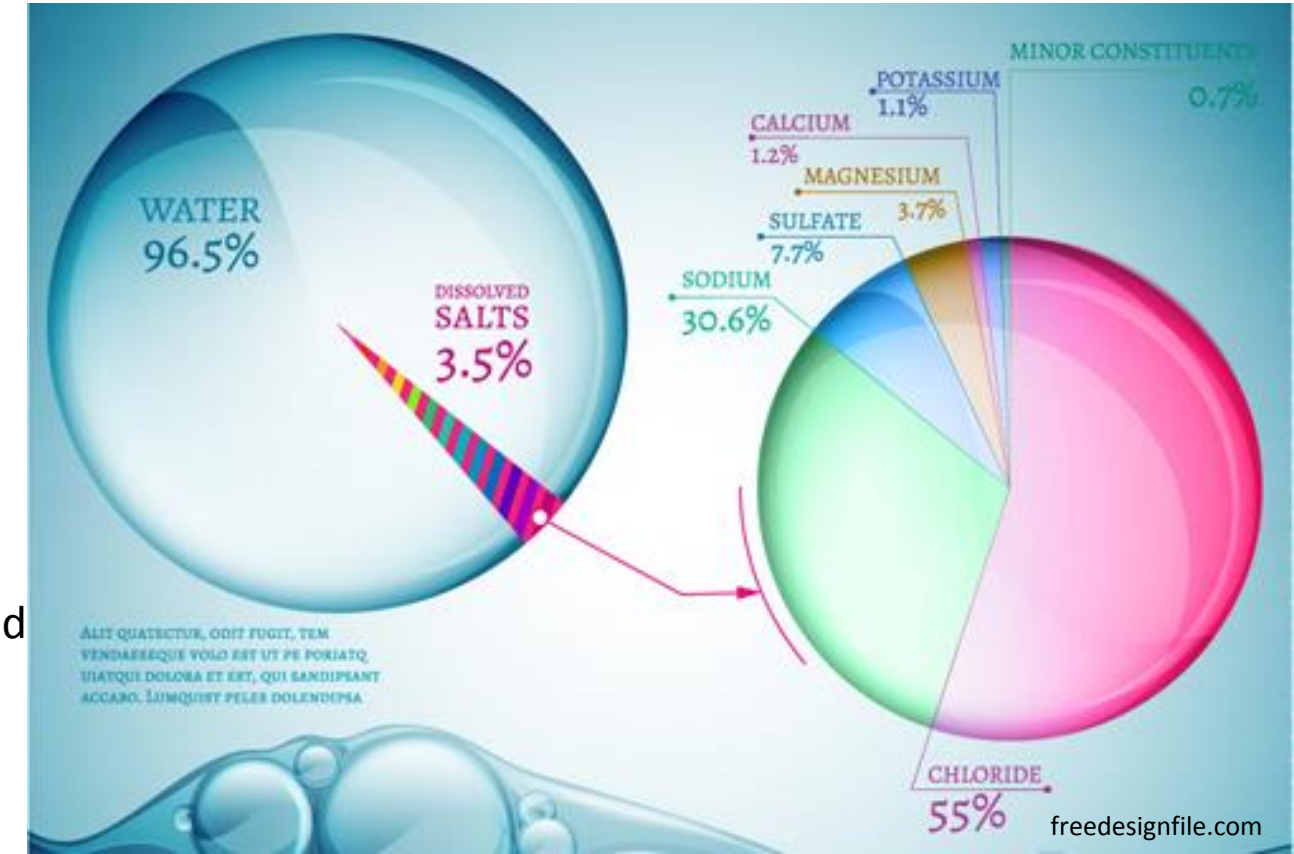
Wyban and Sweeny, 1991

- Potassium (K)
- Magnesium (Mg)
- Calcium (Ca)

- Ca: K 1: 1

- Water supplementation
- Supplementation with food

Costs!



SEA SALT

SW- Sea water; 1 – Instant Ocean; 2 - Tropic Marin; 3 - Marine Mix; 4 - Reef Crystal; 5 – Rea Sea Salt; 6 – Kent; 7- Coralife; 8 – SeaChem' MW – molar mass (g/mol)

	SW	1	2	3	4	5	6	7	8	MW
ppt	35	29.65	32.64	29.40	28.91	30.07	28.85	28.39	29.54	
Major Cations (mmol kg^{-1})										
Na^{+}	470	462	442	467	461	472	460	464	504	23.0
K^{+}	10.2	9.4	9.1	10.1	9.5	9.9	10.1	9.3	10.7	39.1
Mg^{+2}	53	52	46	53	50	55	57	63	37	24.3
Ca^{+2}	10.3	9.4	9.1	10.1	9.5	9.9	10.1	9.3	10.7	40.1
Sr^{+1}	0.09	0.19	0.08	0.15	0.08	0.10	0.10	0.08	0.21	87.6
Sum	607	594	561	601	589	610	605	620	609	
Major Anions (mmol kg^{-1})										
Cl^{-}	550	521	497	538	520	537	531	566	516	35.5
SO_4^{-2}	28	23	21	28	27	25	24	15	37	32.1
TCO_2	1.90	1.90	1.10	2.10	0.75	1.08	2.52	0.32	0.12	12.0
TB	0.42	0.44	0.36	0.41	0.65	0.54	0.54	1.26	4.90	10.8
Sum	608	569	541	596	574	588	582	597	595	
Nutrients (µmol kg-1)										
PO_4:P	0.20	0.05	1.20	0.46	0.32	0.37	0.16	0.95	0.57	31.0
NO_3:N	0.20	1.00	2.20	1.63	5.00	0.79	2.05	6.30	18.4	14.0
NH_4:N	0.20	10.2	0.55	9.2	7.8	5.2	11.9	8.4	0.7	14.0
SiO_3:Si	5	4.2	3.2	11.5	5.9	4.5	4.1	2.7	11.3	28.1
DOP:P	0.2	0.1	0	0.2	0.2	0.1	0.1	0.2	0.1	31.0
DON:N	10	2.9	5.5	8.2	6.3	1.9	2.4	11.2	3.1	14.0
TOC:C	50	29	32	29	28	29	28	28	22	12.0
pH	8.25	8.35	8.90	8.49	9.28	8.69	8.08	9.17	8.81	
TA	2.3	2.3	1.5	3.1	3.2	1.6	2.7	1.5	2.2	

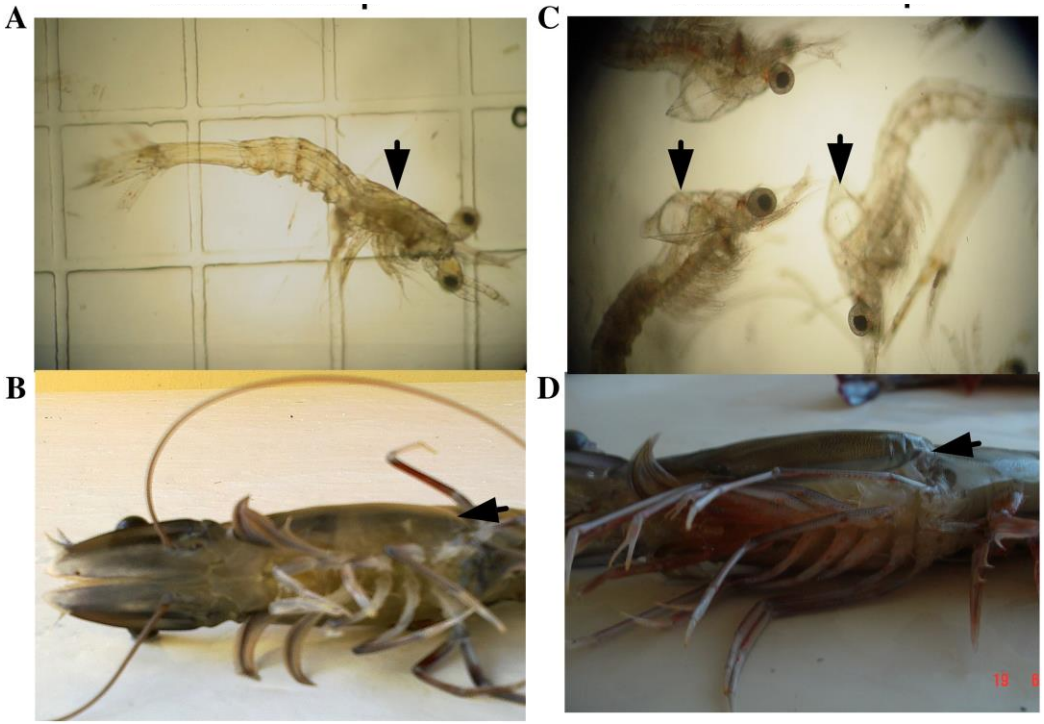
Tropic Marin®
The aquatic life science company

Atkinson, M. J., & Bingman, C. (1997). Elemental composition of commercial seasalts. Journal of Aquariculture and Aquatic Sciences, 8(2), 39-43.

SALT SHORTAGE OR SURPLUS

Mineral deposition on shrimp

L. vannamei A - M3 in salinity 20; B – adult in salinity 5; C - M3 in salinity 32; D – adult in salinity 32.



(Chong-Robles et al. 2014)

Figure 10: Normal *L. vannamei*.

Figure 11: Mineral deposition initial stage of the *L. Vannamei*.

Figure 12: Severe mineral deposited on *L. vannamei*.

(Sakthivel et al., 2014)

SALINITY (DENSITY)

- During RAS operating salinity is controlled by adding the water from the spare tanks. The spare water tanks should be filled with water with lower salinity then in the system.

- <u>It should be remembered that water salinity stabilizes a few hours after adding salt</u>.

Photo: Halina Kendzierska

LIGHT

- Direct sun or moon light may cause algae to grow (even low natural lighting). Unless algae do not harm the shrimp, they increase the cost and time of keeping tanks clean.
- The light : dark regime must be set (e.g. 14 h : 10 h). It is recommended to set light phase for 12 h minimum.

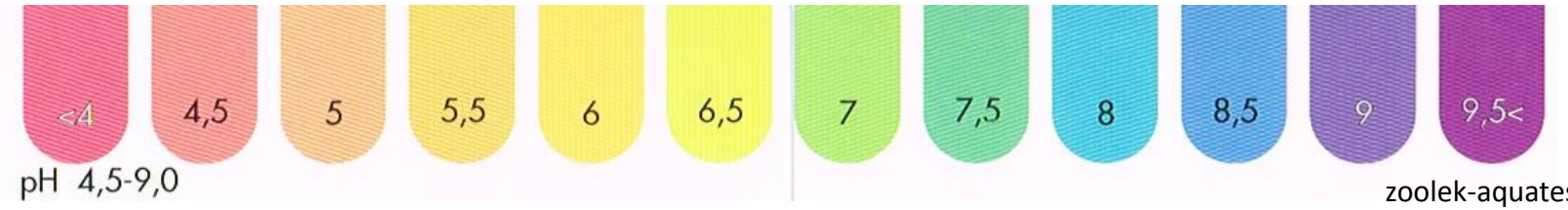
Photo: Halina Kendzierska

OXYGEN

- The oxygen concentration is measured directly or by measuring the RedOx potential;
- Aeration by immersion diffusers and aerators;
- Oxygen is consumed by the shrimp, but also by the bacteria in the biological filter;
- Aeration naturally increases the pH of the water.

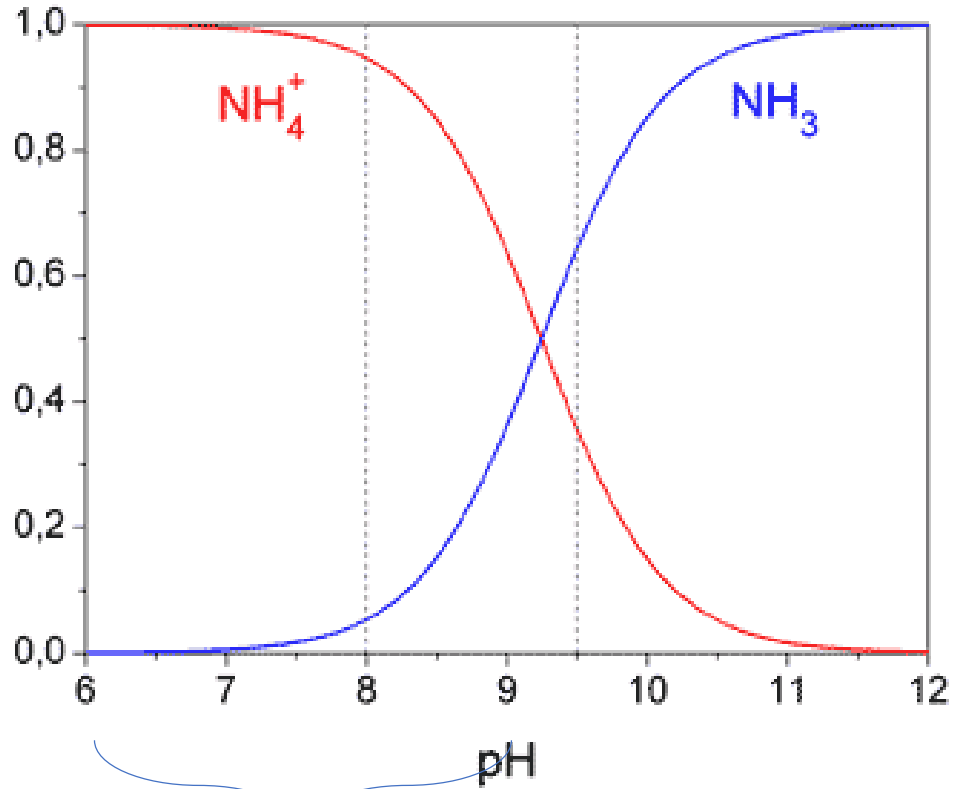
Photo: Halina Kendzierska

AMMONIA AND pH



zoolek-aquatest-phx2

Ammonium

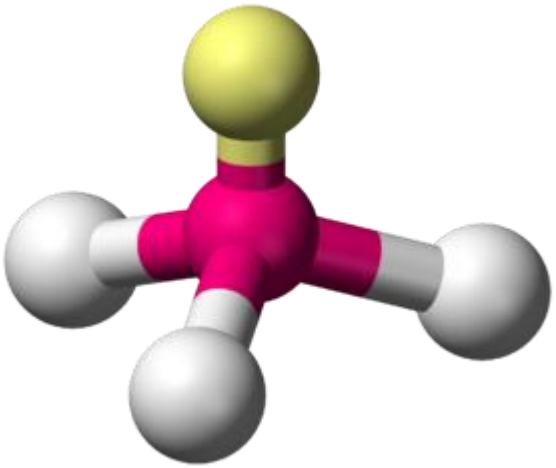


Ammonia

ach.upol.cz

AMMONIA AND NOX

- Ammonia is a product of the metabolism of amino acids;
- Ammonia is toxic to living organisms, irritating;
- The lethal concentration (LC50) in white shrimp during 96-hour exposure is 1.20-2.95 mg / L,
- The concentration of NH3-N 0.45 mg / L reduces the growth rate of shrimp by 50% (Boyd 2013);
- Ammonia incl. significantly reduces the resistance of *L. vannamei* to selected bacterial infections (Liu and Chen 2004);



NOx is even more dangerous than ammonia, especially in water with a low pH, the nitric acid is formed.

rworava.sk

DEVELOPMENT OF THE BIOLOGICAL FILTER

Development of the nitrification deposit :

- Filling the tank with biologically stable water;
- The use of filter media with bacteria cultures;
- Addition of bacterial cultures;
- Adding food to the tank before introducing organisms;
- Addition of pure ammonia (pH> 7) or ammonium chloride (pH <7).

*Size estimation of the biological filter in planned RAS.

www.bersatuharga.id

Generate ozone - not only kills pathogens, but also supports biological filtration.

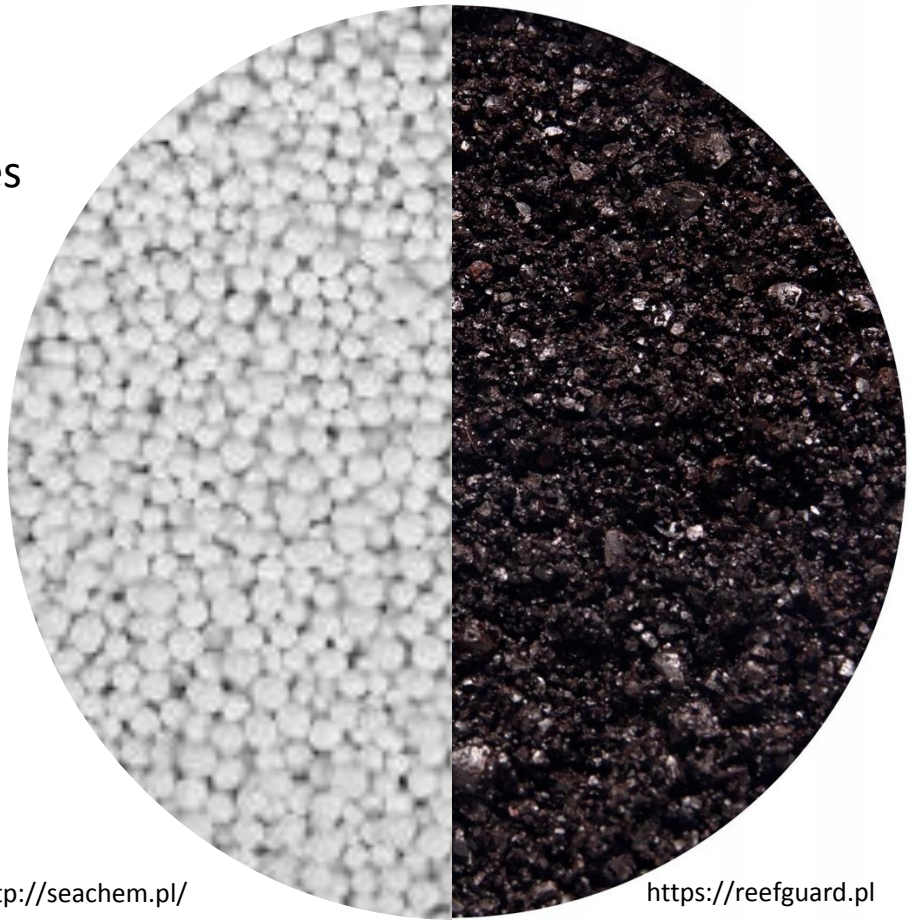
http://bioaqua.vn

OTHER NUTRIENTS

Nutrient control is crucial in preventing the growth of algae biomass in the system.

- high-performance absorbent;
- no influence on the pH of the water;
- does not release hazardous substances into water (e. g. aluminum);

- Phosphates PO_4^{3-}
- SiO_2 silicates



http://seachem.pl/

https://reefguard.pl

Feeding

Juvenile shrimp should be feed with 15-20% of weight per day. For adult shrimp smaller feed dose should be provided 3.4-5%.

For 100 juvenile shrimps (3 g/spec.) 15 % ww ~ 45 g/day.
For 100 shrimps (6 g/spec.) 3.5 % ww ~ 21 g/day.

Regular shrimps fresh mass analysis allow recalculation of the day dose setting of automatic feeders.

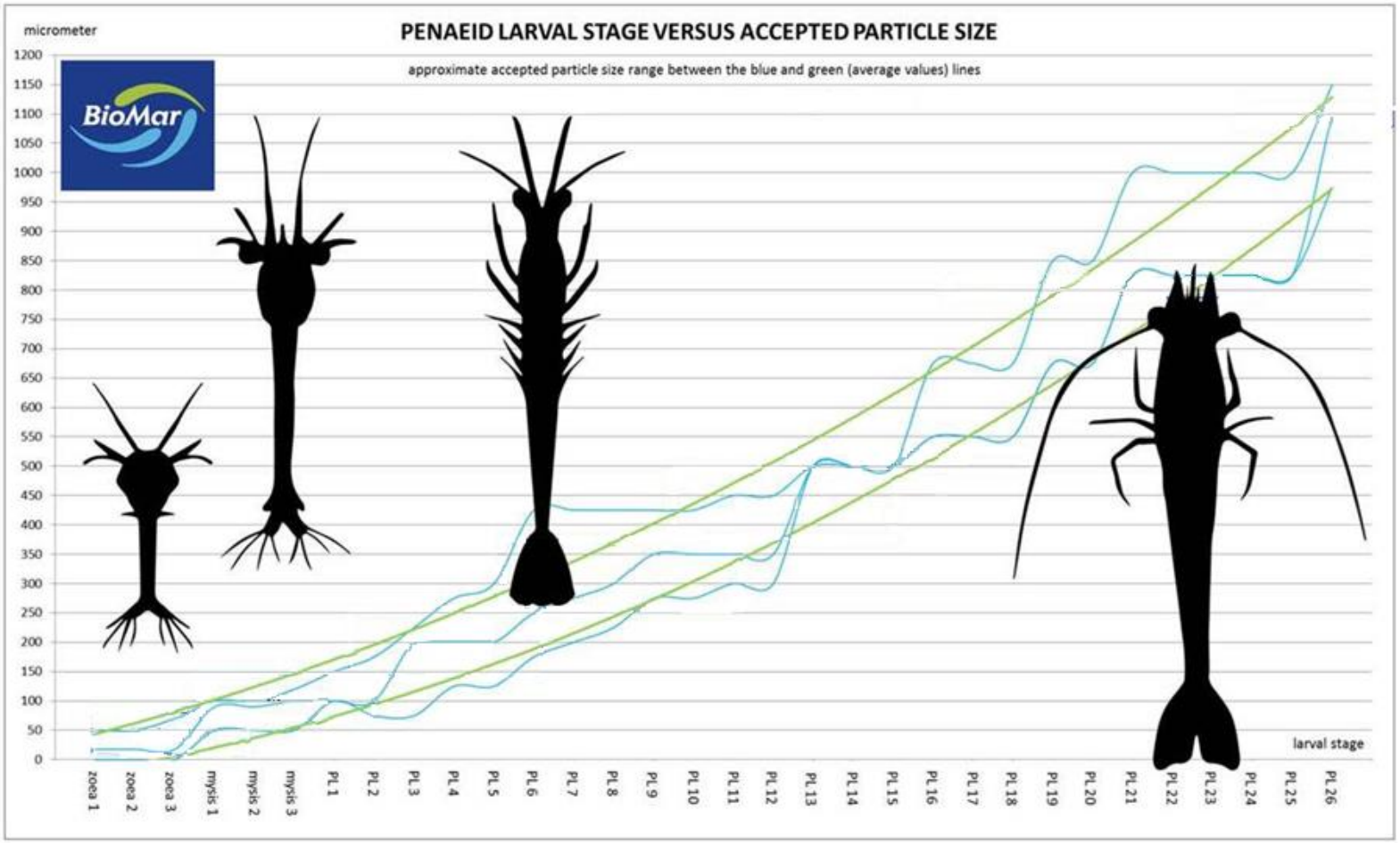

Photo: Piotr Kendzierski

Parameters of feeds used in trials

	Size (mm)	Proteins (%)	Lipids (%)	Ash (%)	Fiber (%)	Phosphorus (%)	Moisture (%)	HUFA (%)	Cholesterol (%)
GEMMA Diamond	0.8-1.5	57	15	10.5	0.2	1.6	No inf.	No inf.	No inf.
CreveTec PL1000	1.0-1.5	min 54	min 12	max 10	max 1	min 1,2	max 10	min 1,6	min 0,5

FEED

~ 5 g specimens can be feed with granules or pellets. Smaller animal should be given ground feed.



BioMar, changed

CANNIBALISM

- In highly transparent water, shrimps can get stressed and attack each other.
- Animals should be feed during first hours of placement to avoid cannibalism. Size and shape of feed need to be suitable to shrimps.
- To avoid cannibalism, shrimps with visible injures or wired behaviour and dead shrimps should be removed from the tanks.
- Stocking densities need to be kept low to prevent cannibalism and rapid growth.

Wu, J. L., Namikoshi, A., Nishizawa, T., Mushiake, K., Teruya, K., & Muroga, K. (2001). Effects of shrimp density on transmission of penaeid acute viremia in Penaeus japonicus by cannibalism and the waterborne route. *Diseases of aquatic organisms*, *47*(2), 129-135.

taranta

SHRIMPS HARVESTING

Shrimps from a tank should be collected rather fast. The stock should be 'ice killed' immediately on harvest and stored in ice.

Specimens chosen to nutrition value analysis should be measured (BL) and frozen in -20 ˚C or -80 ˚C.

Photo: Halina Kendzierska

Photo: Halina Kendzierska

UTILIZATION OF WATER FROM TANKS

In RAS system, wastewater from shrimp culture is reused after it has been treated in various ways.

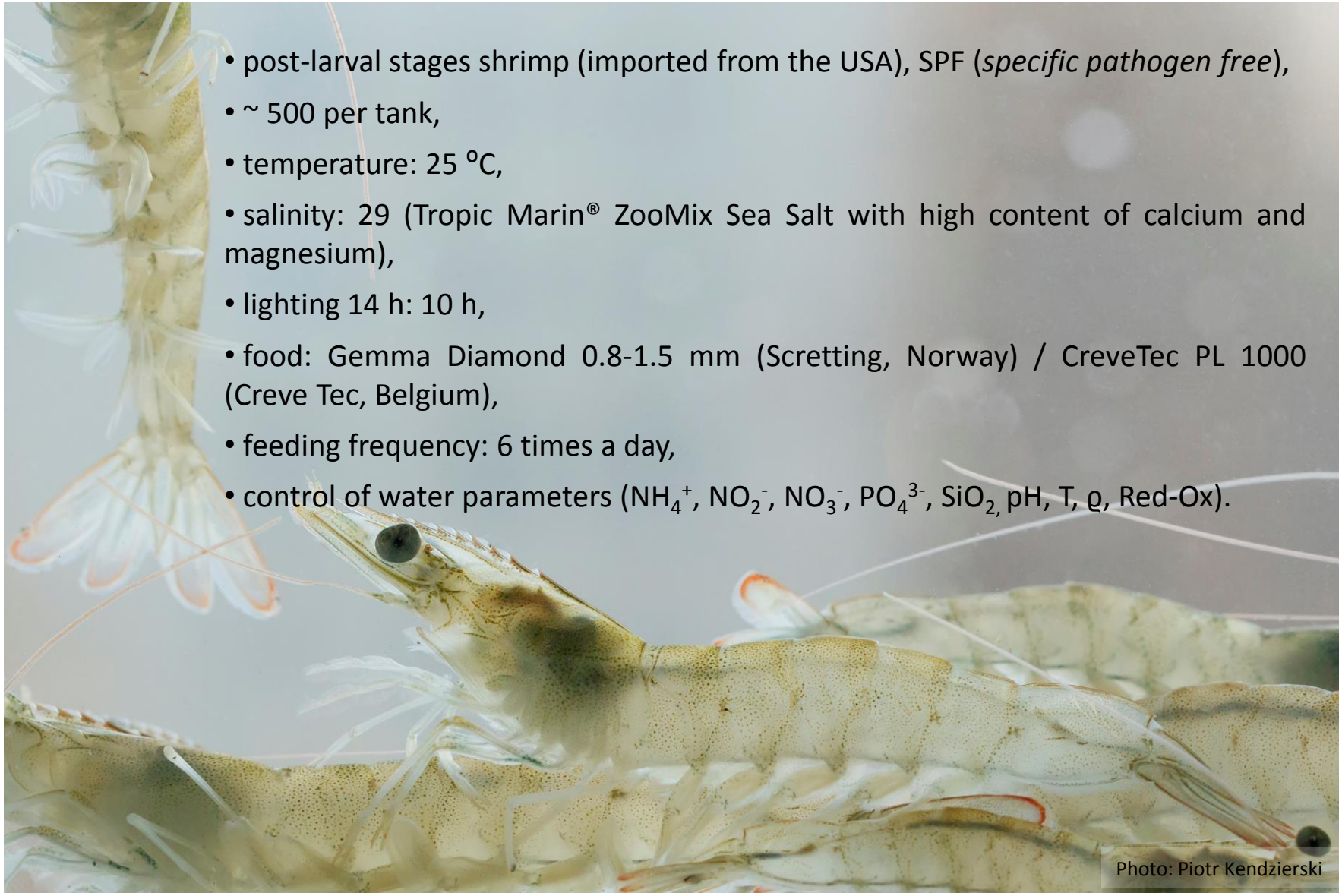
All water from tanks should be drain to sterilizer for UV radiation. Also, water from cleaning should be radiated before drain.

Every pollution incident and it must be reported to the local authority.

Water disinfection is conducted by ozonation or UV irradiation.

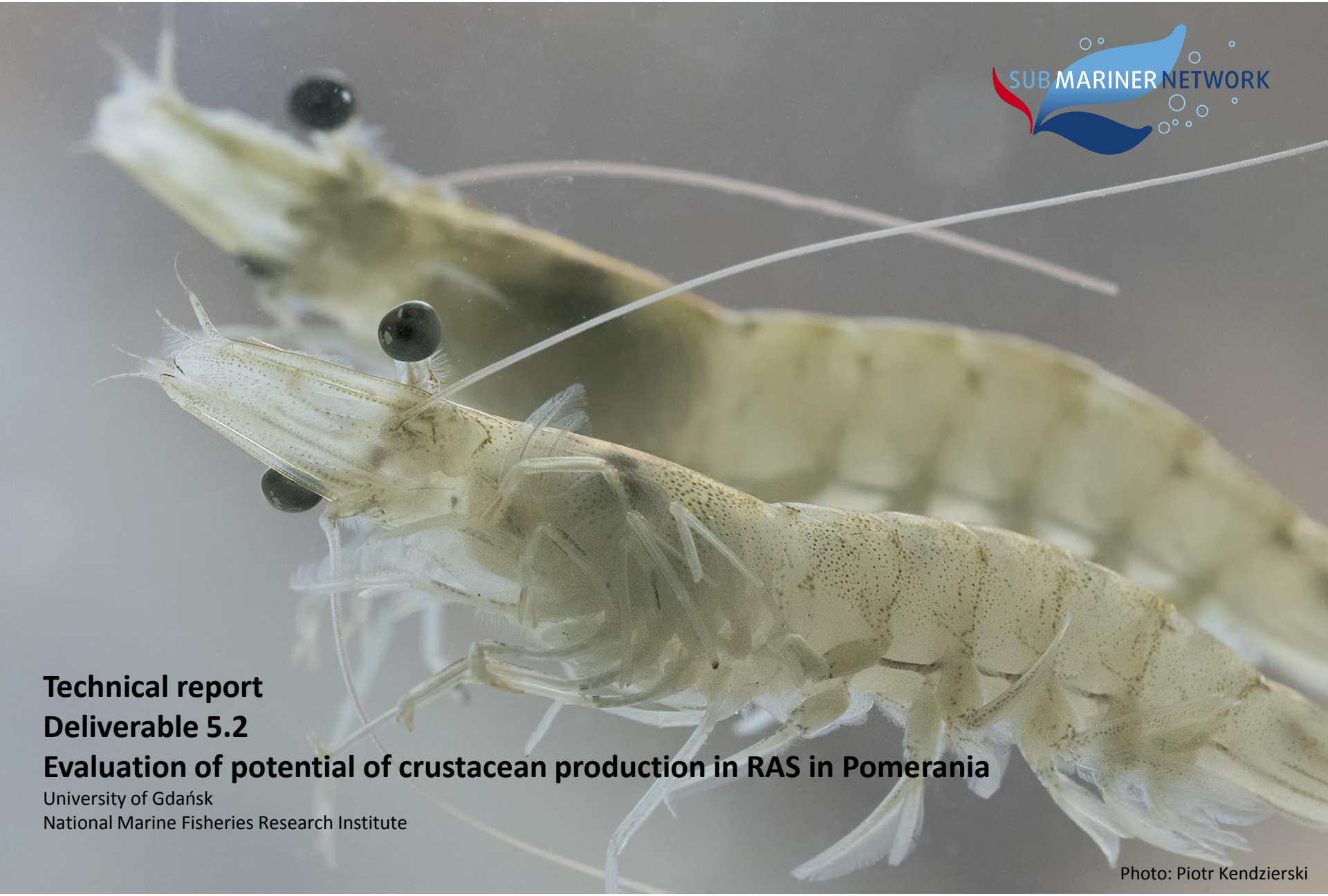
Photo: Halina Kendzierska

THE FIRST EXPERIMENTAL SHRIMP FARM IN POLAND



- post-larval stages shrimp (imported from the USA), SPF (*specific pathogen free*),
- ~ 500 per tank,
- temperature: 25 ^{o}C,
- salinity: 29 (Tropic Marin® ZooMix Sea Salt with high content of calcium and magnesium),
- lighting 14 h: 10 h,
- food: Gemma Diamond 0.8-1.5 mm (Scretting, Norway) / CreveTec PL 1000 (Creve Tec, Belgium),
- feeding frequency: 6 times a day,
- control of water parameters (NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, SiO_2, pH, T, ϱ, Red-Ox).

Photo: Piotr Kendzierski



Technical report
Deliverable 5.2
Evaluation of potential of crustacean production in RAS in Pomerania

University of Gdańsk
National Marine Fisheries Research Institute

Photo: Piotr Kendzierski

http://aquavip.edu.pl

Zdjęcie: Piotr Kendzierski